

Count the Kinds: Measuring Schoolyard Biodiversity with Quadrats

Investigation question: Does a regularly mowed lawn or a less-managed patch of the schoolyard hold more plant biodiversity, and how many quadrats does it take to find out?

Classroom field investigation

Groups of 4

2 sessions

Setup 10 · Activity 80 · Cleanup 10 min

MS-LS2-4 · practice

MS-LS2-5 · supports

Scientific purpose

Students measure plant biodiversity in two patches of the schoolyard that people manage differently. Using 50 cm quadrats placed by dice roll, they build a shared key of plant kinds, record the first plant touched at 25 grid points in each quadrat, and calculate species richness and Simpson's index for each patch. Pooling class data on a species-accumulation graph shows whether the sample was large enough. The lab turns biodiversity from a word into a measurement and gives students their own evidence about how one change people make, mowing, affects which plants grow and how evenly they are mixed.

Why this helps students with this chapter

Biodiversity is easy to talk about and hard to measure. Doing it themselves shows students that richness and evenness are different, that where you put a quadrat changes the answer, and that a careful scientist asks whether the sample was big enough before comparing two places. These are the same measurements conservation teams use to decide whether a plan is working, so the lab sets up the evaluation work in Lab 3 and the kākāpō task.

Standards connections

MS-LS2-4 (practice, constructing an argument from empirical evidence that a change to an ecosystem component (mowing) affects plant populations): Students collect their own field data and argue whether mowing changes which plants grow and how evenly they are mixed (q8). The data are real but come from two patches that differ in more than mowing and from a small sample, so the lab builds the argument practice rather than assessing the full Grade 7 PE.

MS-LS2-5 (supports, measuring biodiversity as the evidence used to evaluate a design solution): Richness and a diversity index are the measurements a team would use to judge whether a plan to maintain or restore biodiversity is working. q10 asks students to design such a before-and-after survey for a school pollinator garden, preparing for the evaluation in Lab 3.

Roles (rotate each session)

- **Site setter:** Rolls the dice, measures out each quadrat position from the baseline, lays the frame, and rerolls if the spot lands on a path, a hazard or an earlier quadrat.

- **Point reader:** Lowers the pointer, blunt end down, through each of the 25 string intersections and calls the code of the first plant touched, or 'bare'.
- **Recorder:** Tallies each call in the hits table, keeps the presence list for each quadrat, and checks that every quadrat totals 25 points.
- **Kind keeper:** Sketches and describes each new plant kind with a hand lens, assigns it the next class code, and checks the group's key against the class chart.

Materials

Item	Quantity	Per	Note
Quadrat frame, 50 cm by 50 cm inside: four 50 cm lengths of half-inch PVC pipe with four elbow joints, or a frame cut from a cardboard box	1	group	Mark 5, 15, 25, 35 and 45 cm on every side with tape.
Cotton string or yarn for the 5 by 5 grid	about 5 m	group	Tie five strings across each way at the tape marks to make 25 intersections.
Wooden barbecue skewers (blunt end used as the pointer) or unsharpened pencils	2	group	
Dice	2	group	Or a printed list of random numbers from 1 to 6.
Hand lens	2	group	
Measuring tape or meter stick for the baseline	1	group	
Flagging tape or small cones to mark the two patches and their baselines	1 roll or 8 cones	class	
Clipboard, pencil and the recording sheet	1 set	student	
Calculator	1	group	
Piece of cardboard or a foam mat to kneel on	2	group	
Disposable gloves (optional, for students with sensitive skin) and hand soap or wipes	1 box and wipes	class	

Estimated cost: 5 to 50 per class (an estimate; Estimate. Cardboard frames from recycled boxes plus string, tape and a pack of skewers cost about 5 dollars per class. Reusable PVC frames for eight groups (eight 2 m lengths of half-inch pipe at about 2 dollars each and 32 elbows at roughly 0.50 to 1 dollar each) add about 35 to 45 dollars and last for years. Dice, hand lenses, calculators and clipboards are typical classroom stock.)

Safety

- Work only in the teacher-checked patches. Poison oak grows at the edges of many California school grounds and causes a severe rash; nettles, thistles and some weeds sting or prick. Do not touch plants you have not been told are safe, and never put plants or fingers in your mouth.

- Bees and wasps visit flowers in less-managed patches, and yellowjackets nest in the ground. Move slowly, do not swat, and step away from any nest. Students allergic to stings carry their prescribed epinephrine auto-injector outdoors, and the teacher knows who they are.
- Skewers have a sharp point: lower them blunt end down, never point them at anyone, and carry them point down. Unsharpened pencils are a safer substitute.
- Do not touch animal droppings, broken glass, needles or other litter; tell the teacher. Do not survey any area that has been sprayed recently.
- On sunny days wear a hat and sunscreen, bring water and take breaks from kneeling in the sun. Watch for sprinkler heads and holes when walking.
- Stay inside the marked patches and within sight of the teacher. Do not pull up or pick plants, and wash hands after the field session.

Teacher preparation and setup

1. A few days ahead, walk the grounds with facilities staff and choose two flat patches near each other, each at least 4 m by 4 m: a regularly mowed lawn and a less-managed patch (an unmowed edge, a weedy margin, a native or pollinator garden, a field corner). Confirm that neither has been sprayed with herbicide, pesticide or fertilizer in the past week, and ask that the lawn not be mowed the day before.
2. Check both patches for hazards and flag or avoid them: poison oak, nettles, thistles and other spiny plants, ant mounds, ground nests of yellowjackets or bees, animal droppings, glass and sprinkler heads. Check the sprinkler schedule.
3. Build the frames and tie the string grid; test one in the lawn to make sure the strings sit just above the plants and the pointer passes cleanly through each intersection.
4. Draw a starter kind key on the board or a class chart with three common lawn plants (for example a fine-bladed grass, a clover with three leaflets, a flat rosette weed with toothed leaves) coded K1 to K3. Groups add new kinds as K4, K5 and so on to the same chart so every group uses the same code for the same plant.
5. Lay a baseline of flagging tape along one edge of each patch and mark it every 50 cm from 0.5 m to 3 m, so a die roll from 1 to 6 gives a position along it.
6. Ask about allergies (stings, grass and pollen). Make sure any student with a prescribed epinephrine auto-injector has it outdoors and that an adult with the group knows how to use it.

Investigation design

Independent variable	How the patch is managed: a regularly mowed lawn compared with a less-managed (unmowed or lightly managed) patch.
Dependent variable	Species richness (kinds on the presence lists), hits per kind at 25 points per quadrat, and Simpson's index for each patch.
Controlled	Same quadrat size (50 cm by 50 cm) and the same 25 grid points; Same first-touch rule with a vertical pointer; Quadrats placed by dice roll, not by choice; Same class kind key and codes; Both patches sampled on the same day
Trials	Three quadrats per patch per group; the class pools 18 to 24 quadrats per patch for the accumulation curve and the class indexes.

Comparison

The two patches are compared with each other, and each group's values are compared with the class-pooled values to see how much small samples vary.

Student procedure

1. Session 1, in class (5 minutes): write your prediction in q1 and answer q2. Look at the starter kind key and agree how your group will tell kinds apart (leaf shape, edges, hairs, how the leaves attach, flowers).
2. At the first patch, the Site setter rolls one die for the position along the baseline (the roll times 50 cm) and the second die for the distance into the patch (the roll times 50 cm, measured with the meter stick), then lays the frame with its corner on that spot. If the frame lands on a path, a flagged hazard or an earlier quadrat, roll again; never move the frame to a spot that looks more interesting.
3. Kind keeper and Recorder list every plant kind rooted inside the frame (the presence list). Each new kind gets the next class code, a sketch and a description in the kind key. Use the hand lens and do not pick the plant.
4. Point reader lowers the pointer, blunt end down, straight through each of the 25 string intersections and calls the code of the first plant it touches; if it reaches soil, mulch or dead leaves without touching a living plant, call 'bare'. Recorder tallies every call. A partner watches that the pointer stays vertical.
5. Repeat steps 2 to 4 for quadrats 2 and 3 in the same patch, then sample three quadrats in the second patch. Note the time, the weather and whether the lawn looks freshly mowed.
6. Session 2: total each patch's hits by kind and leave 'bare' out of the plant total. For each kind compute $p = \text{hits} \div \text{plant total}$, square it, add the squares, and compute Simpson's index $D = 1 - (\text{sum of } p^2)$.
7. Count each patch's richness: all kinds on your presence lists, whether or not the pointer hit them. Fill the accumulation table by counting how many kinds each quadrat added that earlier quadrats of the same patch had not.
8. Copy your group's totals to the class chart. Using the class data in the order groups sampled, plot total kinds found against number of quadrats sampled for each patch on one graph, one color per patch. Compute the class Simpson's index for each patch from the pooled hits.
9. Answer q3 and q4 on the recording sheet as a group, then the analysis questions individually.

Expected observations

- Mowed lawn quadrats usually show about 2 to 6 kinds, with one or two grasses taking most of the 25 points; Simpson's index often falls roughly between 0.2 and 0.5.
- Less-managed patches usually show more kinds (often 4 to 10 per quadrat) in a more even mix, giving indexes around 0.5 to 0.8, though a mulched bed with a few shrubs can score lower than a weedy lawn.
- Accumulation curves rise steeply over the first few quadrats and then flatten; the less-managed patch usually needs more quadrats before it flattens.
- Bare points are more common in garden beds and trampled areas; leaving them out of the plant total keeps the index about the plants only.
- Group values for the same patch can differ by several kinds and by 0.1 to 0.2 in the index, while the class-pooled values are steadier.

Likely difficulties

- Deciding whether two plants are the same kind: young and old leaves can look different. The Kind keeper compares with the class chart, lumps when unsure, and notes the decision.
- Placing quadrats by eye instead of by the dice, drifting toward interesting plants. The Site setter role and q2 exist to prevent this.
- Counting 'bare' in the plant total, or forgetting to square the proportions. Work patch X from q5 on the board before session 2.
- Several grasses look alike. Treat all fine-bladed grasses as one kind unless the difference is obvious, and record this as a limitation.
- Wet grass soaks knees and recording sheets; use kneeling mats and clipboards with a plastic sleeve, or wait for the lawn to dry.

Structured debrief

1. Write each group's richness and index for both patches on the board beside the class-pooled values. Ask why groups disagree and why the pooled value is more trustworthy: more quadrats, more of the rare kinds found, less chance that one odd quadrat swings the result.
2. Show the accumulation curves. Where a curve flattens, extra quadrats add few new kinds; if it is still climbing, richness is underestimated. Connect to the named-species bar graph: Earth's species list is a curve that has not flattened, which is why scientists keep finding new species.
3. Compare the two measures using patches X and Y from q5: same richness, very different index. Ask when richness and the index could rank your own patches differently, and which question each measure answers.
4. Raise the health question from slide 17: is the less-managed patch healthier? Ask which kinds are native and which are lawn weeds from other continents. Point ahead to Lab 3: measurements like these are how a team would tell whether a plan to restore a habitat is working.

Recording sheet: what students fill in

Lab 1 recording sheet: Count the Kinds

You will sample **three quadrats in Patch A** (mowed lawn) and **three in Patch B** (less-managed patch). In each quadrat, list every plant kind you see (the presence list), then record the **first plant touched** at each of the 25 grid points. A point that touches only soil, mulch or dead leaves is **bare**. Use the class codes (K1, K2, ...) so every group means the same plant by the same code.

1. Prediction: which patch will have more plant kinds, and which will have a more even mix? Explain your reasoning using what mowing does to plants.

Answer: Predictions vary. A typical well-reasoned prediction: Patch B will have more kinds and a more even mix, because mowing cuts down tall and flowering plants again and again, while lawn grasses regrow from their base and spread to cover most of the ground.

Why: This is a prediction, so it is graded on reasoning, not on whether it turns out right.

Also acceptable: Predicting that the lawn has more kinds because many small weeds hide in it earns credit if the reason is stated.

- Names a patch for richness and for evenness
- Gives a reason tied to what mowing does to plants

2. Why does the Site setter place quadrats by dice roll instead of choosing spots that look interesting? What would go wrong otherwise?

Answer: Random placement keeps the sample fair and representative. If we chose spots, we would tend to pick places with interesting or flowering plants, which would overestimate richness and make the comparison between patches depend on our choices instead of on the patches.

Why: The point is avoiding bias so the sample stands for the whole patch.

- Mentions bias or choosing interesting spots
- Explains that the sample should represent the whole patch

Kind key (add each new kind the first time you see it)

Code	Description (leaf shape, edges, hairs, flowers)	Quick sketch	In Patch A?	In Patch B?
K1				
K2				
K3				
K4				
K5				
K6				
K7				
K8				
K9				
K10				

Point-intercept hits (tally the first plant touched at each of the 25 points)

Kind	A: Q1	A: Q2	A: Q3	A total	B: Q1	B: Q2	B: Q3	B total
K1								
K2								

Kind	A: Q1	A: Q2	A: Q3	A total	B: Q1	B: Q2	B: Q3	B total
K3								
K4								
K5								
K6								
K7								
K8								
K9								
K10								
Bare (soil, mulch, dead leaves)								
Check: all points	25	25	25	75	25	25	25	75

Presence lists and accumulation

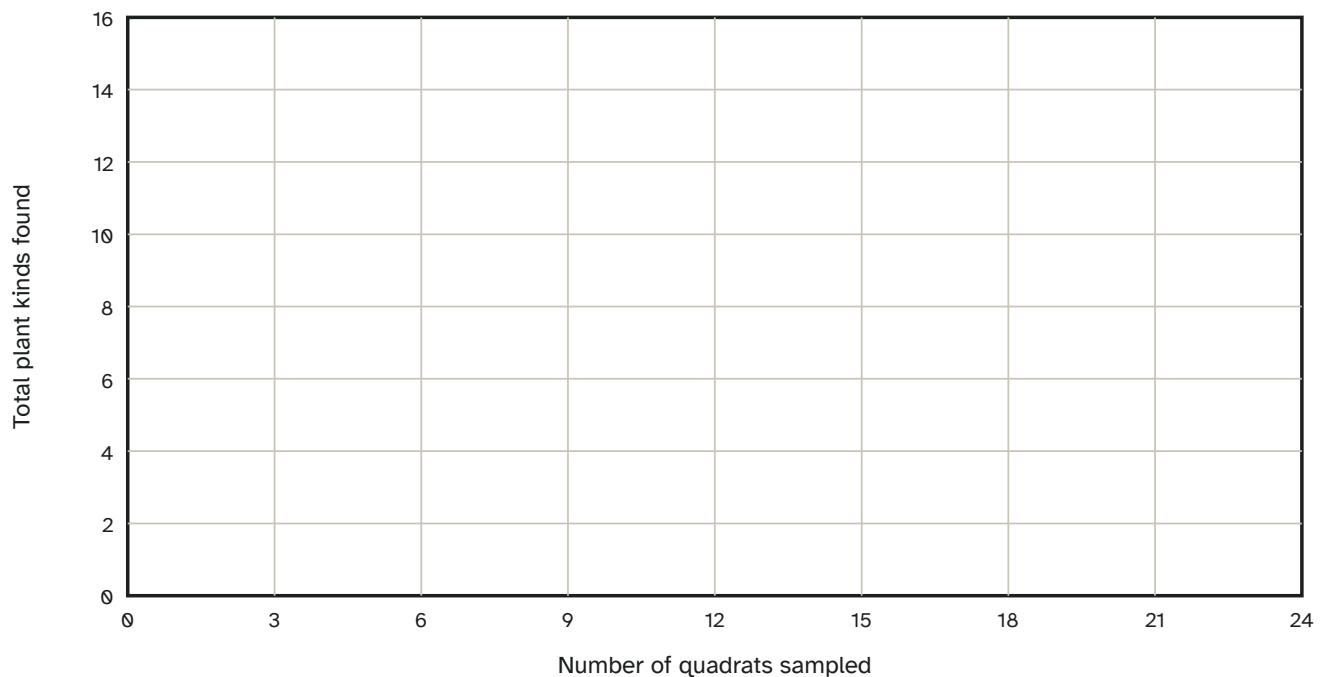
Patch and quadrat	Codes of kinds present	Number present	New kinds (not in earlier quadrats of this patch)	Total kinds found so far in this patch
A, quadrat 1				
A, quadrat 2				
A, quadrat 3				
B, quadrat 1				
B, quadrat 2				
B, quadrat 3				

Simpson's index: $p = \text{hits} \div \text{plant total (leave out bare)}$; $D = 1 - \text{sum of } p^2$

Kind	Patch A hits	A: p	A: p^2	Patch B hits	B: p	B: p^2
K1						
K2						
K3						
K4						
K5						
K6						
K7						

Kind	Patch A hits	A: p	A: p ²	Patch B hits	B: p	B: p ²
K8						
K9						
K10						
Plant total (no bare)		1.00			1.00	
Sum of p ²						
Simpson's index D						

Kinds found as more quadrats are sampled (class data)



3. Report richness and Simpson's index for each patch, from your group's data and from the class data. Which patch has higher biodiversity by each measure?

Answer: Depends on the site. A typical result: Patch A (lawn) class richness about 4 to 6 kinds, class D about 0.3; Patch B class richness about 8 to 12 kinds, class D about 0.7. Patch B is higher by both measures.

Why: Check that each value follows from the student's own tables: D computed from pooled hits without bare points, richness from presence lists.

- Richness and D given for both patches, group and class
- Correct statement of which patch is higher by each measure
- Values consistent with the recorded data

4. Look at the accumulation curves. Did each curve level off? What does that tell you about whether the class found most of the kinds in each patch?

Answer: Depends on the data. If a curve flattens over the last several quadrats, the class has probably found most of the kinds in that patch; if it is still rising at the end, more kinds remain to be found and richness is an underestimate. Usually the lawn curve flattens sooner than the less-managed patch's.

Why: Students should read the shape of the curve, not just the final number.

- Describes each curve's shape at the end
- Connects flattening to having found most kinds
- Draws a conclusion about whether richness is underestimated

Analysis questions: answer key

5. Another class surveyed two patches with the same four plant kinds. Patch X had 40, 20, 10 and 10 plant hits; Patch Y had 74, 2, 2 and 2. Compute Simpson's index for each patch, showing your work, and explain which has higher biodiversity even though both have a richness of 4.

Answer: Patch X: plant total = $40 + 20 + 10 + 10 = 80$; $p = 0.5, 0.25, 0.125, 0.125$; $p^2 = 0.25, 0.0625, 0.015625, 0.015625$; sum = 0.34375 ; $D = 1 - 0.34375 = \mathbf{0.66}$. Patch Y: total = $74 + 2 + 2 + 2 = 80$; $p = 0.925, 0.025, 0.025, 0.025$; $p^2 = 0.855625, 0.000625, 0.000625, 0.000625$; sum = 0.8575 ; $D = 1 - 0.8575 = \mathbf{0.14}$. Patch X has higher biodiversity because its plants are shared more evenly; in Patch Y one kind covers 92.5 percent of the points.

Why: Both patches have the same richness, so the difference comes entirely from evenness, which Simpson's index captures and richness does not.

Also acceptable: 0.656 and 0.143 (or 0.1425) are equally correct.

- Correct totals and proportions
- D for X about 0.66 and for Y about 0.14
- Explains the difference as evenness

6. Compare your two patches using both richness and Simpson's index from the class data. Is the difference between the patches bigger than the differences among quadrats within one patch? Use numbers.

Answer: Depends on the data. A strong answer gives both class values (for example lawn richness 5, D 0.30; less-managed richness 10, D 0.72), gives the range among quadrats within each patch (for example lawn quadrats 2 to 4 kinds, less-managed 4 to 8), and concludes whether the between-patch difference is larger than the within-patch spread.

Why: Comparing the difference between groups with the variation within groups is how students judge whether a difference is meaningful.

- Uses both richness and D
- States the within-patch spread with numbers
- Concludes whether the patches truly differ

7. Your group's three quadrats and the class's 18 or more quadrats probably gave different richness for the same patch. Explain why, and say which value you trust more.

Answer: A few quadrats can miss rare kinds or land on an unusual spot, so a small sample gives a lower and more variable richness. The class value, from many more quadrats, finds more of the rare kinds and averages out odd quadrats, so it is more trustworthy.

Why: Larger samples reduce chance effects; richness in particular rises as more area is searched.

- Explains that small samples miss rare kinds or vary by chance
- Chooses the class value with a reason

8. Write an argument: does mowing change which plants grow and how evenly they are mixed? State a claim, cite at least two numbers, explain the cause (what mowing does to tall plants compared with low-growing ones), and name one other difference between the patches that could also explain your result.

Answer: Example: Claim: mowing reduces both the number of plant kinds and the evenness of the mix.

Evidence: the lawn had 5 kinds and $D = 0.30$ while the less-managed patch had 10 kinds and $D = 0.72$; one grass took about 80 percent of the lawn's points. Reasoning: mowing repeatedly removes the tops of tall and flowering plants, while lawn grasses grow from a point near the ground and recover, so grasses spread and other plants are crowded out. Other explanation: the patches also differ in water, soil, shade, foot traffic or what was planted.

Why: This is the argument practice of MS-LS2-4 with the student's own empirical data; an honest competing explanation is required because the comparison is not a controlled experiment.

Also acceptable: If the data showed little difference or the reverse, a claim that mowing had little effect at this site, supported by the numbers, earns full credit.

- Clear claim about mowing
- At least two numbers from the data
- Mechanism explaining how mowing favors some plants
- At least one competing explanation

9. A classmate says the patch with the higher Simpson's index is 'healthier'. What else would you need to know before agreeing? Think about native and invasive plants.

Answer: I would need to know which kinds are native and which are invasive or lawn weeds from elsewhere, what plants that kind of place naturally holds, and whether the plants support native insects and birds. A high index can come from many invasive weeds.

Why: Health is judged by the integrity of the natural set of species, not by a diversity score alone.

- Mentions native versus invasive or non-native
- Mentions comparing with what naturally belongs or with the animals supported

10. The school plans to turn half of the lawn into a native pollinator garden. Design a before-and-after survey to judge whether the change increases biodiversity: what you would measure, how many quadrats, when, and one measurable criterion for success.

Answer: Example: measure plant richness and Simpson's index with the same 50 cm point-intercept quadrats, plus a count of flowering kinds and of bees and butterflies seen in 10 minutes. Sample at least 10 random quadrats in the planned garden area and 10 in the remaining lawn, in the spring before planting and again in the same month one and two years later. Success criterion: in year 2 the garden has at least twice the lawn's richness and a Simpson's index above 0.6, with native kinds making up most hits.

Why: A good monitoring design compares before and after, includes a comparison area, keeps the method and season the same, and states a measurable criterion.

- Names specific measurements
- States sample size and timing (before and after, same season)
- Includes a comparison area or baseline
- States a measurable criterion

11. Name two limitations of the point-intercept method for measuring plant biodiversity, and say how each could bias your result.

Answer: Any two: only the first plant touched is counted, so short plants under taller ones are missed (biases toward tall plants); small or rare kinds may never be hit (lowers the index); lumping look-alike kinds lowers richness and splitting one kind raises it; hits measure cover, not numbers of plants; different readers may judge the first touch differently.

Why: Students should connect each limitation to the direction it could push the result.

- Two genuine limitations
- A likely effect on the result for each

Individual evidence of learning

Each student submits their own copy of the hits table, the Simpson's calculation for both patches, the class accumulation graph and answers to q1 through q11. The calculations and graph show measurement skill; q8 is the evidence-based argument about a change to an ecosystem; q10 shows that the student can design the kind of monitoring that would evaluate a biodiversity solution.

Assessment criteria

Criterion	Proficient looks like
Data collection	Quadrats placed by dice roll; 25 points recorded per quadrat with the first-touch rule; presence lists complete; kind key sketches clear enough for another group to use.
Calculation	Proportions, squares, sums and Simpson's index correct for both patches with bare points excluded; q5 correct to two decimal places with work shown.
Sampling judgment	Uses the shape of the accumulation curve and the spread of group values to judge whether enough quadrats were sampled (q4, q7).
Argument from evidence	q8 states a claim about mowing, cites at least two numbers, explains the mechanism, and names a competing explanation.

Accessibility adaptations

- Choose patches beside a hard path so students using wheelchairs or walkers can reach the frame; a longer pointer such as a 60 cm dowel lets a seated student make the point readings.
- Students with grass or pollen allergies can work as Recorder at the patch edge, or build the kind key indoors from photos of each quadrat taken by the group.
- Provide a calculation template with the p, p² and sum columns set up, and allow a calculator or spreadsheet.
- Offer a bilingual word bank for the kind key (leaf, edge, toothed, smooth, hairy, rosette, blade, leaflet, flower).
- Provide large-print recording sheets and a magnifier for students with low vision; the hand lens task can be shared.

Low-cost alternative

Make frames from cardboard and string, use pencils as pointers and a random-number list instead of dice. If no outdoor site is safe or available, run an indoor bead-tray model: two trays of mixed dried beans or beads stand for two patches with known counts, and students sample each with a card punched with 25 holes. They compute richness and Simpson's index from their samples and compare them with the true values, which also shows how sample size affects an estimate.

Model limitations

This activity has not been physically tested by the authors; the ranges in the expected observations are estimates, and a teacher's trial run on the chosen site is the real guide. Plant 'kinds' are look-alike groups rather than identified species, so richness can be undercounted (similar grasses lumped) or overcounted (young and old leaves of one plant split). Point-intercept hits measure cover, not numbers of individual plants, and they miss small or rare kinds that the presence list catches. Six quadrats per group is a small sample. The two patches differ in more than mowing (soil, water, shade, foot traffic, past planting), so the comparison suggests but cannot prove that mowing is the cause. Plants are only one part of biodiversity; insects and soil life are not counted.

Teacher notes

Run the method yourself on the chosen patches a few days ahead; the expected ranges here are estimates, not tested results. Work patch X from q5 on the board before students calculate their own index: it fixes the two most common errors (counting bare points and forgetting to square). For the class accumulation curve, enter quadrats in the order groups finished sampling; a curve built in a different order will look slightly different but should flatten at about the same height. Grade q3, q4 and q6 against the student's own tables rather than against the typical values. If the less-managed patch is a garden bed full of mulch, many bare points are expected and its index may be lower than the lawn's; that is a legitimate result and a good debrief discussion.